

That Which is Claimed Is:

1. A semiconductor structure for light emitting devices that can emit in the red to ultraviolet portion of the electromagnetic spectrum, said structure comprising:

a first n-type cladding layer of  $\text{Al}_x\text{In}_y\text{Ga}_{1-x-y}\text{N}$ , where  $0 \leq x \leq 1$  and  $0 \leq y < 1$  and  $(x + y) \leq 1$ ;

a second n-type cladding layer of  $\text{Al}_x\text{In}_y\text{Ga}_{1-x-y}\text{N}$ , where  $0 \leq x \leq 1$  and  $0 \leq y < 1$  and  $(x + y) \leq 1$ , wherein said second n-type cladding layer is further characterized by the substantial absence of magnesium;

an active layer of  $\text{Al}_x\text{In}_y\text{Ga}_{1-x-y}\text{N}$ , where  $0 \leq x < 1$  and  $0 \leq y \leq 1$  and  $(x + y) \leq 1$ , wherein said active layer is n-type and is positioned between said first n-type cladding layer and said second n-type cladding layer; and

a p-type layer of a Group III nitride, wherein said second n-type cladding layer is positioned between said p-type layer and said active layer;

wherein said first and second n-type cladding layers have respective bandgaps that are each larger than the bandgap of said active layer.

2. A semiconductor structure according to Claim 1, wherein said active layer has a first surface and a second surface, said first surface of said active layer being in contact with said first n-type cladding layer and said

second surface of said active layer being in contact with said second n-type cladding layer.

3. A semiconductor structure according to Claim 1,  
5 wherein said second n-type cladding layer has a first surface and a second surface, said first surface of said second n-type cladding layer being in contact with said active layer, and said second surface of said second n-type cladding layer being in contact with said p-type layer,  
10 wherein the composition of said second n-type cladding layer is progressively graded such that the crystal lattice at said first surface of said second n-type cladding layer more closely matches the crystal lattice of said active layer, and the crystal lattice at said second surface of  
15 said second n-type cladding layer more closely matches the crystal lattice of said p-type layer.

4. A semiconductor structure according to Claim 1,  
wherein said p-type layer is in contact with said second n-  
20 type cladding layer, opposite said active layer.

5. A semiconductor structure according to Claim 1,  
wherein said second n-type cladding layer consists  
essentially of  $\text{Al}_x\text{Ga}_{1-x}\text{N}$ , where  $0 < x < 1$ .

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6. A semiconductor structure according to Claim 1,  
wherein said active layer consists essentially of  $\text{In}_y\text{Ga}_{1-y}\text{N}$ ,  
where  $0 < y < 1$ .

5           7. A semiconductor structure according to Claim 1,  
wherein said p-type layer is magnesium-doped gallium  
nitride.

10           8. A semiconductor structure according to Claim 7,  
wherein said second n-type cladding layer is thick enough  
to deter migration of magnesium from said p-type layer to  
said active layer, yet thin enough to facilitate  
recombination in said active layer.

15           9. A semiconductor structure according to Claim 1,  
wherein said p-type layer is indium nitride.

20           10. A semiconductor structure according to Claim 1,  
wherein said p-type layer is  $\text{In}_x\text{Ga}_{1-x}\text{N}$ , where  $0 < x < 1$ .

25           11. A semiconductor structure according to Claim 1,  
wherein said p-type layer comprises a superlattice formed  
from a plurality of Group III nitride layers selected from  
the group consisting of gallium nitride, indium nitride,  
and  $\text{In}_x\text{Ga}_{1-x}\text{N}$ , where  $0 < x < 1$ .

12. A semiconductor structure according to Claim 11,  
wherein said superlattice is formed from alternating layers  
of two Group III nitride layers selected from the group  
consisting of gallium nitride, indium nitride, and  $\text{In}_x\text{Ga}_{1-x}\text{N}$ ,  
5 where  $0 < x < 1$ .

13. A semiconductor structure according to Claim 1,  
further comprising a third n-type layer of  $\text{Al}_x\text{In}_y\text{Ga}_{1-x-y}\text{N}$ ,  
where  $0 \leq x \leq 1$  and  $0 \leq y < 1$  and  $(x + y) \leq 1$ , wherein said  
10 third n-type layer is positioned between said second n-type  
cladding layer and said p-type layer.

14. A semiconductor structure according to Claim 13,  
wherein said third n-type layer has a first surface and a  
15 second surface, said first surface of said third n-type  
layer being in contact with said p-type layer and said  
second surface of said third n-type layer being in contact  
with said second n-type cladding layer.

15. A semiconductor structure according to Claim 1,  
further comprising an n-type silicon carbide substrate,  
wherein said first n-type cladding layer is positioned  
between said silicon carbide substrate and said active  
layer.

16. A semiconductor structure according to Claim 15,  
further comprising discrete crystal portions selected from

the group consisting of gallium nitride and indium gallium nitride, said discrete crystal portions positioned between said first n-type cladding layer and said silicon carbide substrate, said discrete crystal portions being present in an amount sufficient to reduce the barrier between said first n-type cladding layer and said silicon carbide substrate, but less than an amount that would detrimentally affect the function of any resulting light emitting device formed on said silicon carbide substrate.

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17. A semiconductor structure according to Claim 1, further comprising:

an n-type-silicon carbide substrate; and

a conductive buffer layer positioned between said silicon carbide substrate and said first n-type cladding layer.

18. A semiconductor structure according to Claim 17, wherein said conductive buffer layer has a first surface and a second surface, said first surface of said conductive buffer layer being in contact with said silicon carbide substrate and said second surface of said conductive buffer layer being in contact with said first n-type cladding layer.

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19. A semiconductor structure according to Claim 17, wherein said conductive buffer layer consists essentially

of aluminum gallium nitride having the formula  $\text{Al}_x\text{Ga}_{1-x}\text{N}$ ,  
where  $0 < x < 1$ .

20. A semiconductor structure according to Claim 17,  
5 further comprising an n-type transition layer of a Group  
III nitride, said transition layer being positioned between  
said conductive buffer layer and said first n-type cladding  
layer.

10 21. A semiconductor structure according to Claim 17,  
further comprising discrete crystal portions selected from  
the group consisting of gallium nitride and indium gallium  
nitride, said discrete crystal portions positioned between  
said conductive buffer layer and said silicon carbide  
15 substrate, said discrete crystal portions being present in  
an amount sufficient to reduce the barrier between said  
conductive buffer layer and said silicon carbide substrate,  
but less than an amount that would detrimentally affect the  
function of any resulting light emitting device formed on  
20 said silicon carbide substrate.

22. A semiconductor structure for light emitting  
devices that can emit in the red to ultraviolet portion of  
the electromagnetic spectrum, said structure comprising:

25 an n-type single crystal silicon carbide substrate of  
a polytype selected from the group consisting of 3C, 4H,  
6H, and 15R;

a p-type layer formed of at least one Group III nitride selected from the group consisting of gallium nitride, indium nitride, and  $\text{In}_x\text{Ga}_{1-x}\text{N}$ , where  $0 < x < 1$ ;

an active layer of  $\text{Al}_x\text{In}_y\text{Ga}_{1-x-y}\text{N}$ , where  $0 \leq x < 1$  and  $0 \leq y \leq 1$  and  $(x + y) \leq 1$ , wherein said active layer is n-type and is positioned between said silicon carbide substrate and said p-type layer;

a first n-type cladding layer of  $\text{Al}_x\text{In}_y\text{Ga}_{1-x-y}\text{N}$ , where  $0 \leq x \leq 1$  and  $0 \leq y < 1$  and  $(x + y) \leq 1$ , wherein said first n-type cladding layer is positioned between said silicon carbide substrate and said active layer;

a second n-type cladding layer of  $\text{Al}_x\text{In}_y\text{Ga}_{1-x-y}\text{N}$ , where  $0 \leq x \leq 1$  and  $0 \leq y < 1$  and  $(x + y) \leq 1$ , wherein said second n-type cladding layer is positioned between said active layer and said p-type layer;

wherein said first and second n-type cladding layers have respective bandgaps that are each larger than the bandgap of said active layer.

23. A semiconductor structure according to Claim 22, wherein said first n-type cladding layer has a first surface and a second surface, said first surface of said first n-type cladding layer being in contact with said silicon carbide substrate, and said second surface of said first n-type cladding layer being in contact with said active layer, wherein the composition of said first n-type cladding layer is progressively graded such that the crystal lattice at said first surface of said first n-type

cladding layer more closely matches the crystal lattice of said silicon carbide, and the crystal lattice at said second surface of said first n-type cladding layer more closely matches the crystal lattice of said active layer.

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24. A semiconductor structure according to Claim 22, wherein said second n-type cladding layer has a first surface and a second surface, said first surface of said second n-type cladding layer being in contact with said active layer, and said second surface of said second n-type cladding layer being in contact with said p-type layer, wherein the composition of said second n-type cladding layer is progressively graded such that the crystal lattice at said first surface of said second n-type cladding layer more closely matches the crystal lattice of said active layer, and the crystal lattice at said second surface of said second n-type cladding layer more closely matches the crystal lattice of said p-type layer.

25. A semiconductor structure according to Claim 22, wherein said p-type layer is magnesium-doped gallium nitride.

26. A semiconductor structure according to Claim 25, wherein said second n-type cladding layer is thick enough to deter migration of magnesium from said p-type layer to said active layer, yet thin enough to facilitate recombination in the active layer.

27. A semiconductor structure according to Claim 22,  
wherein said p-type layer comprises a superlattice formed  
from alternating layers of two Group III nitride layers  
5 selected from the group consisting of gallium nitride,  
indium nitride, and  $\text{In}_x\text{Ga}_{1-x}\text{N}$ , where  $0 < x < 1$ .

28. A semiconductor structure according to Claim 22,  
further comprising a third n-type layer of  $\text{Al}_x\text{In}_y\text{Ga}_{1-x-y}\text{N}$ ,  
10 where  $0 \leq x \leq 1$  and  $0 \leq y < 1$  and  $(x + y) \leq 1$ , wherein said  
third n-type layer is positioned between said second n-type  
cladding layer and said p-type layer.

29. A semiconductor structure according to Claim 22,  
15 wherein said third n-type layer has a first surface and a  
second surface, said first surface of said third n-type  
layer being in contact with said p-type layer and said  
second surface of said third n-type layer being in contact  
with said second n-type cladding layer.

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30. A semiconductor device according to Claim 22,  
further comprising a conductive buffer layer consisting  
essentially of aluminum gallium nitride having the formula  
 $\text{Al}_x\text{Ga}_{1-x}\text{N}$ , where  $0 \leq x \leq 1$ , said conductive buffer layer  
25 positioned between said silicon carbide substrate and said  
first n-type cladding layer.

31. A semiconductor structure according to Claim 30,  
further comprising an n-type transition layer of a Group  
III nitride, said transition layer being positioned between  
said conductive buffer layer and said first n-type cladding  
5 layer, and having the same conductivity type as said first  
n-type cladding layer.

32. A semiconductor structure according to Claim 22,  
further comprising discrete crystal portions selected from  
10 the group consisting of gallium nitride and indium gallium  
nitride, said discrete crystal portions positioned between  
said first n-type cladding layer and said silicon carbide  
substrate, said discrete crystal portions being present in  
an amount sufficient to reduce the barrier between said  
15 first n-type cladding layer and said silicon carbide  
substrate, but less than an amount that would detrimentally  
affect the function of any resulting light emitting device  
formed on said silicon carbide substrate.